Flasher Correlates for Calibration and ν_e Reconstruction

Sourav K. Mandal
SKMandal@lbl.gov

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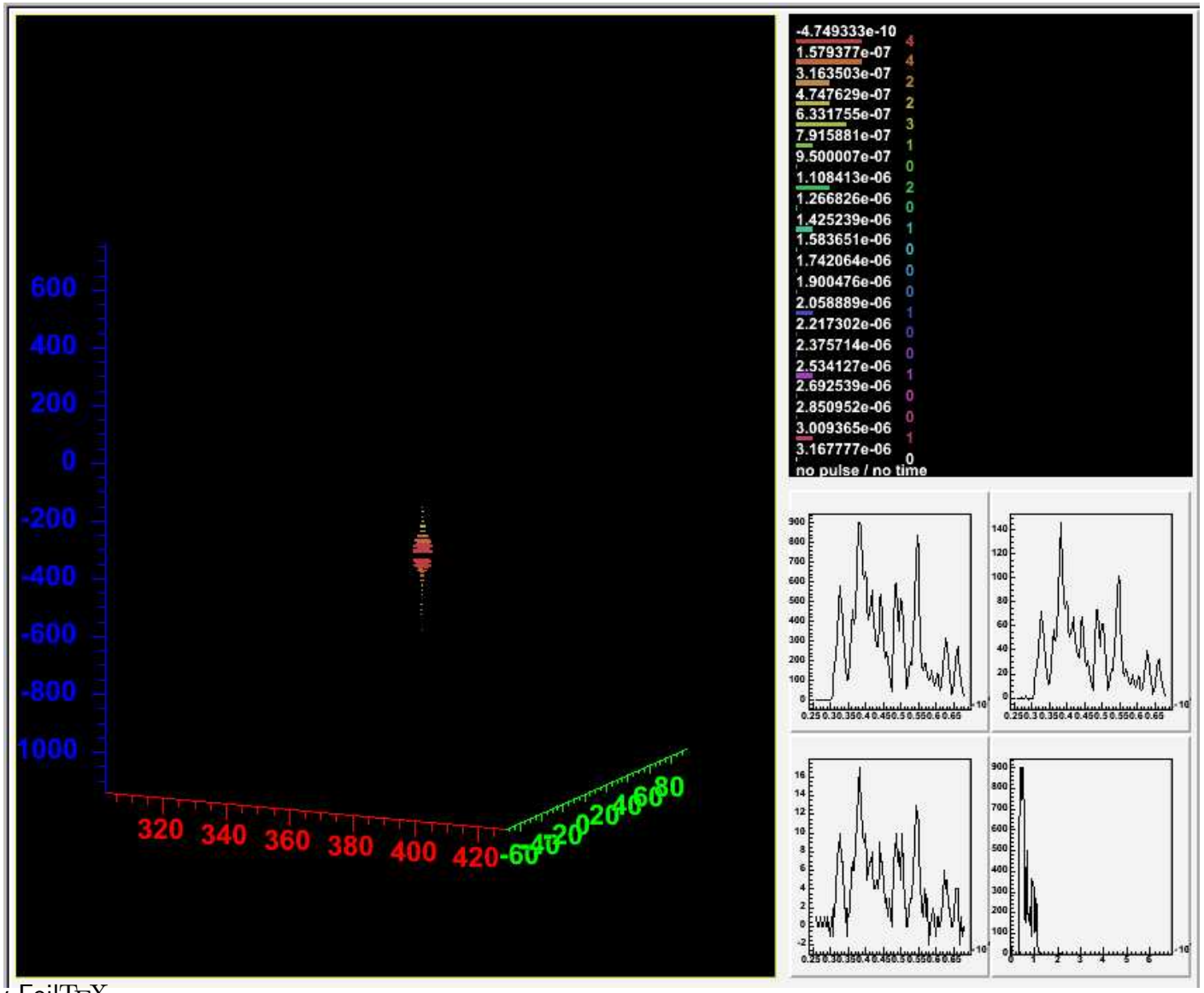
Abstract

I examine the relationship between DOM position and various waveform properties, such as width and total charge, to aid in ν_e cascade reconstruction and ice modeling.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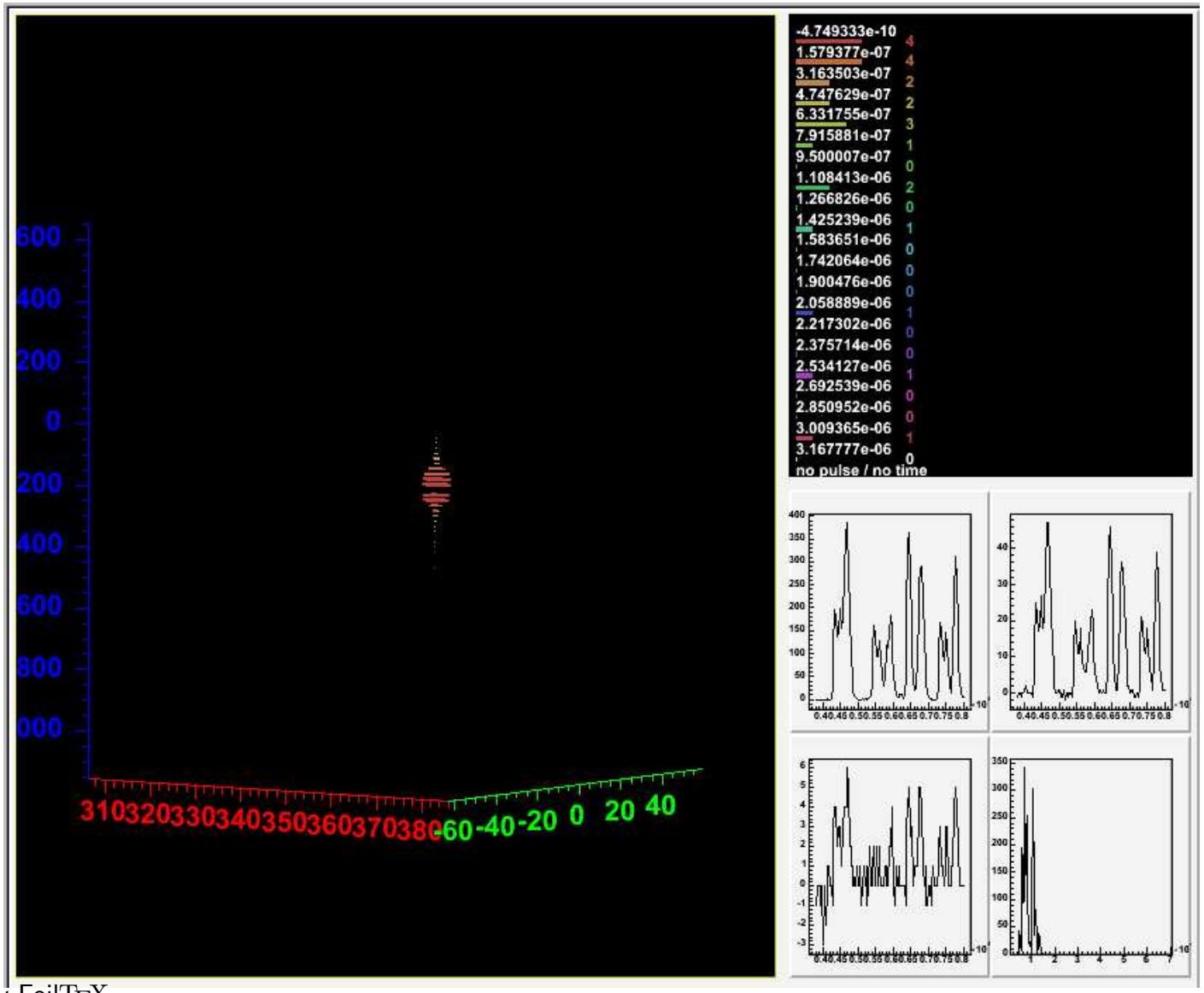
3.163503e-07
4.747629e-07
6.331755e-07
7.915881e-07
9.500007e-07
1.108413e-06
1.266826e-06
1.425239e-06
1.583651e-06
1.742064e-06
1.900476e-06
2.058889e-06
2.217302e-06
2.375714e-06
2.534127e-06
2.692539e-06
2.850952e-06
3.009365e-06
3.167777e-06
no pulse / no time
600
400
200
0
-200
-400
-600
-800
1000
320 340 360 380 400 420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3.009365e-06
3.167777e-06
no pulse / no time
600
400
200
0
200
400
600
800
000
-60 -40 -20 0 20 40

Goals of Flasher Analysis

- Build map relating waveform properties to distance and orientation from cascade vertex, for speedy reconstruction
- Verify simulation
- Characterize ice and test photon propagation models

Here: Characterize flasher data and simulated data sets

Software Setup

- Flasher data
  - Data from recent TestDAQ flasher runs:
    - 0011541: DOM 10, brightness 64
    - 0011557: DOM 30, brightness 64
    - 0011562: DOM 50, brightness 64
    - 0011565: DOM 50, brightness 127

    20 ns flasher pulse, all LEDs, low rate to avoid saturation
  - Read with FAT-reader
  - Inspection to cull muon events

- Cascade simulation

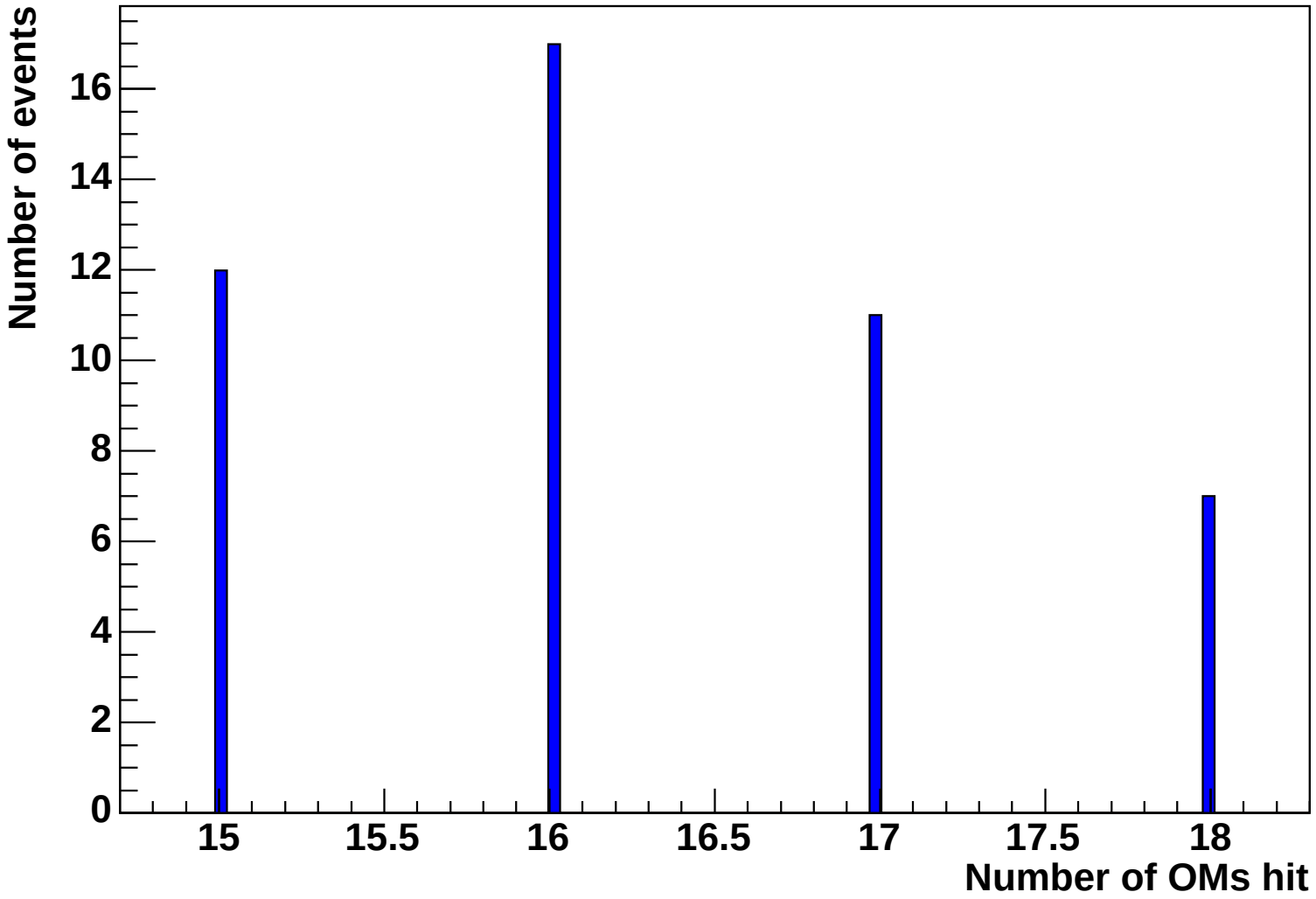
- Tom McCauley's `cascade-generator` in simulation trunk
- 500 GeV, String 21 DOM 30, $\theta = 90^\circ$
- Single photoelectrion waveform $\sim$2x too big – ad hoc correction
- Bulk ice!

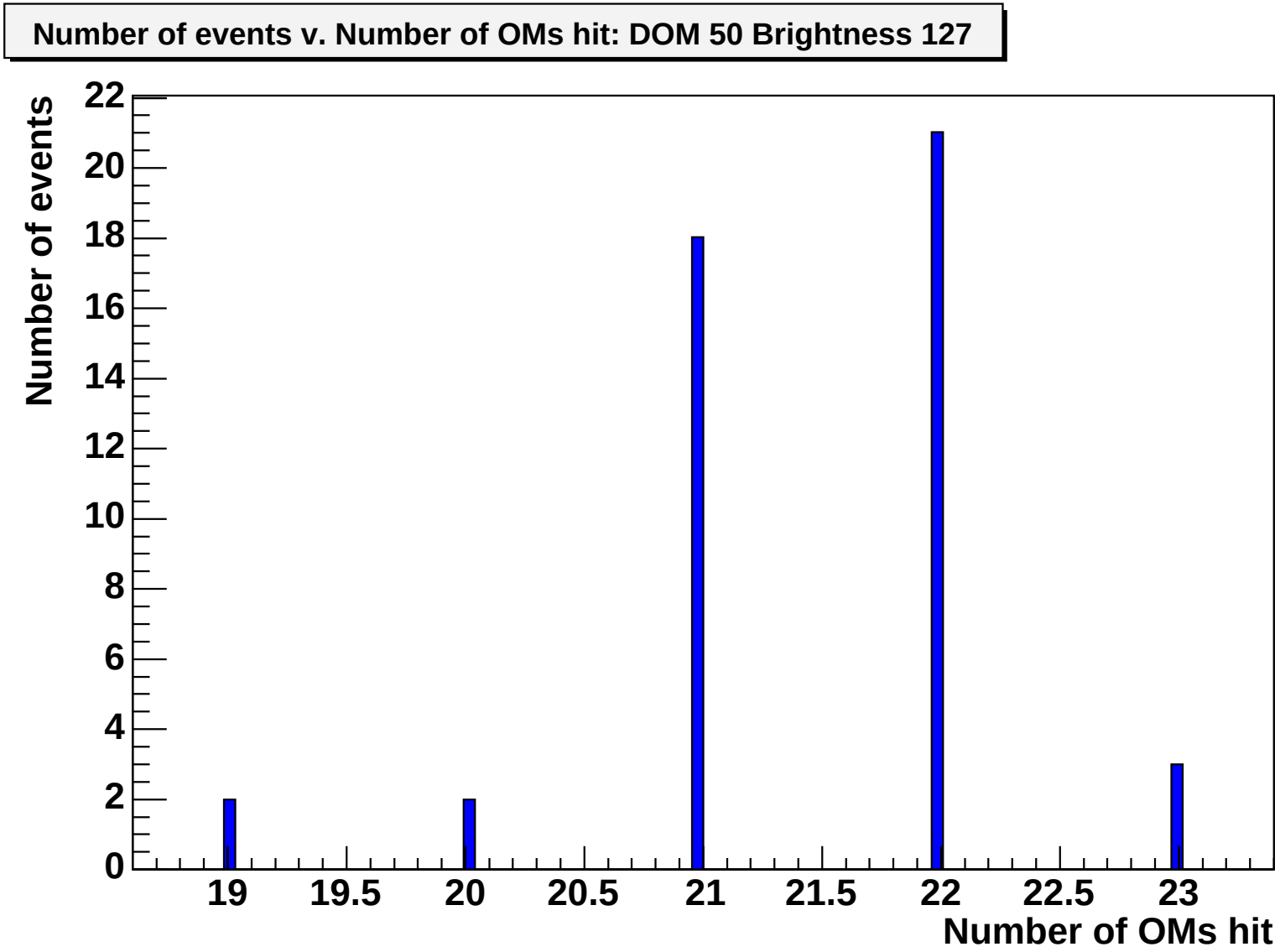
Items of general interest

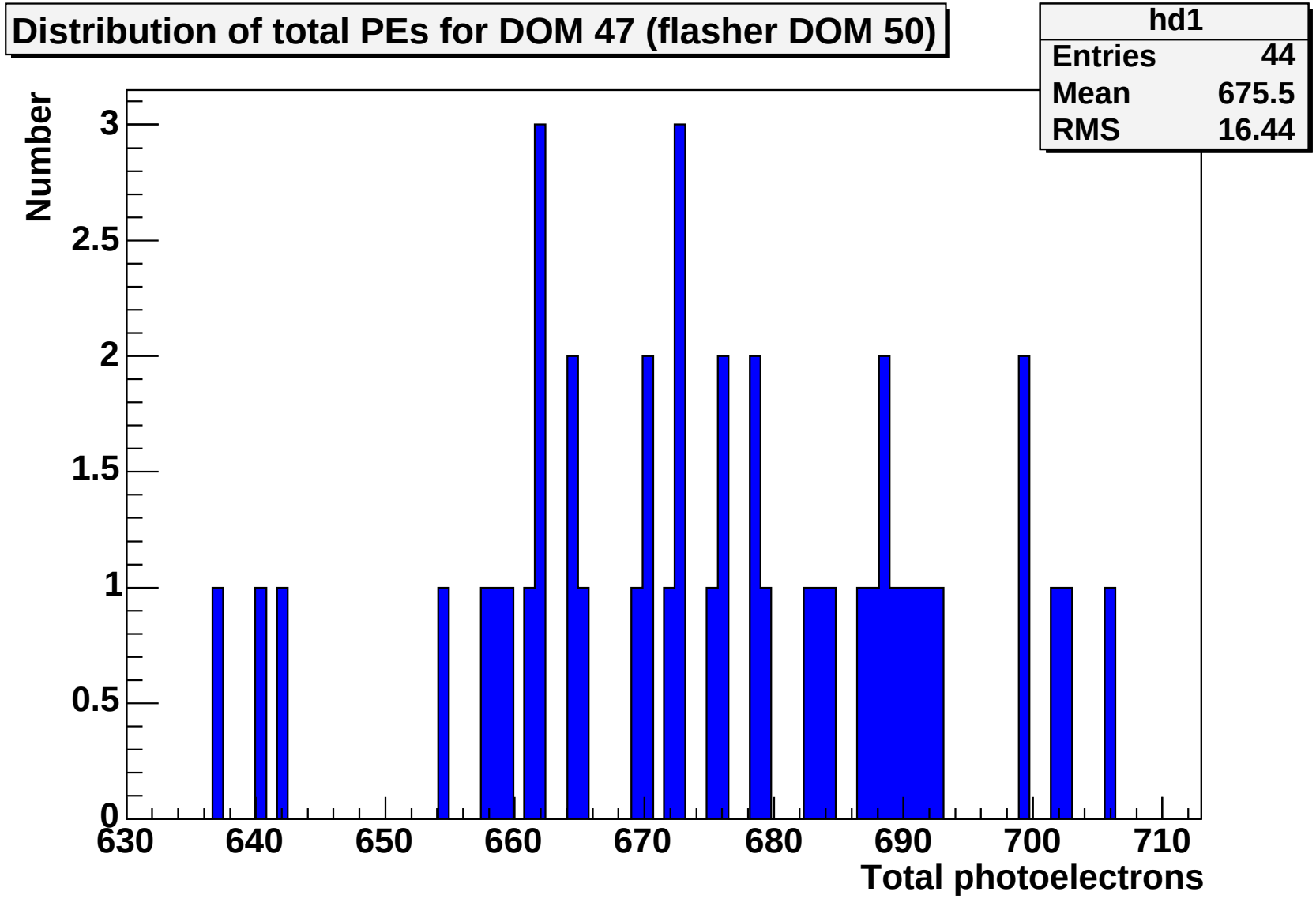
- Number of hit DOMs depending on brightness – 64 and 127 for DOM 50

- Flasher repeatability: distribution in total signal for a single DOM in a run

Number of events v. Number of OMs hit: DOM 50 Brightness 64




Number of events v. Number of OMs hit: DOM 50 Brightness 127
Number of events
0
2
4
6
8
10
12
14
16
18
20
22
19
19.5
20
20.5
21
21.5
22
22.5
23
Number of OMs hit

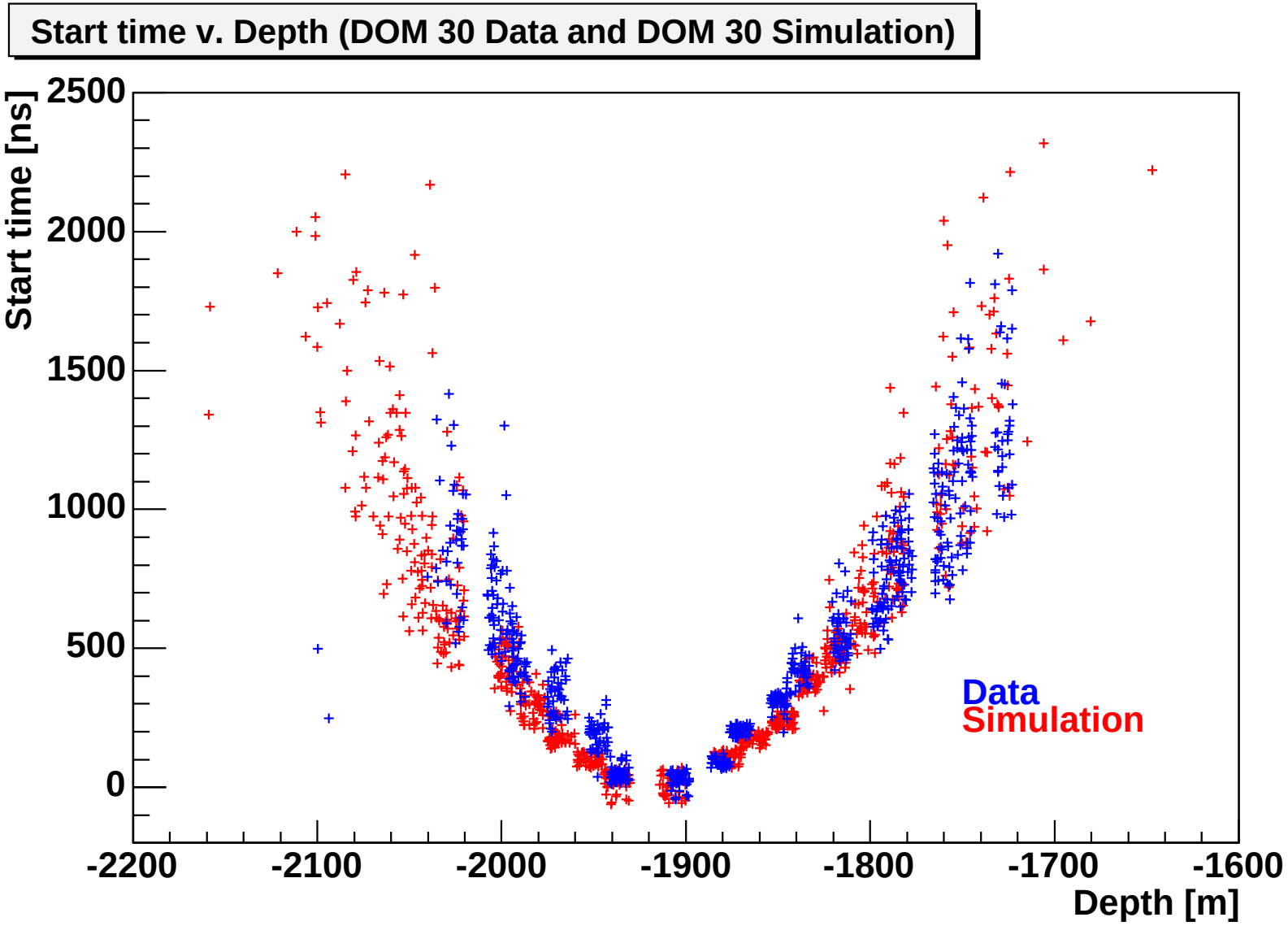

Distribution of total PEs for DOM 47 (flasher DOM 50)
hd1
Entries 44
Mean 675.5
RMS 16.44
Number
0
0.5
1
1.5
2
2.5
3
630
640
650
660
670
680
690
700
710
Total photoelectrons

Waveform start times

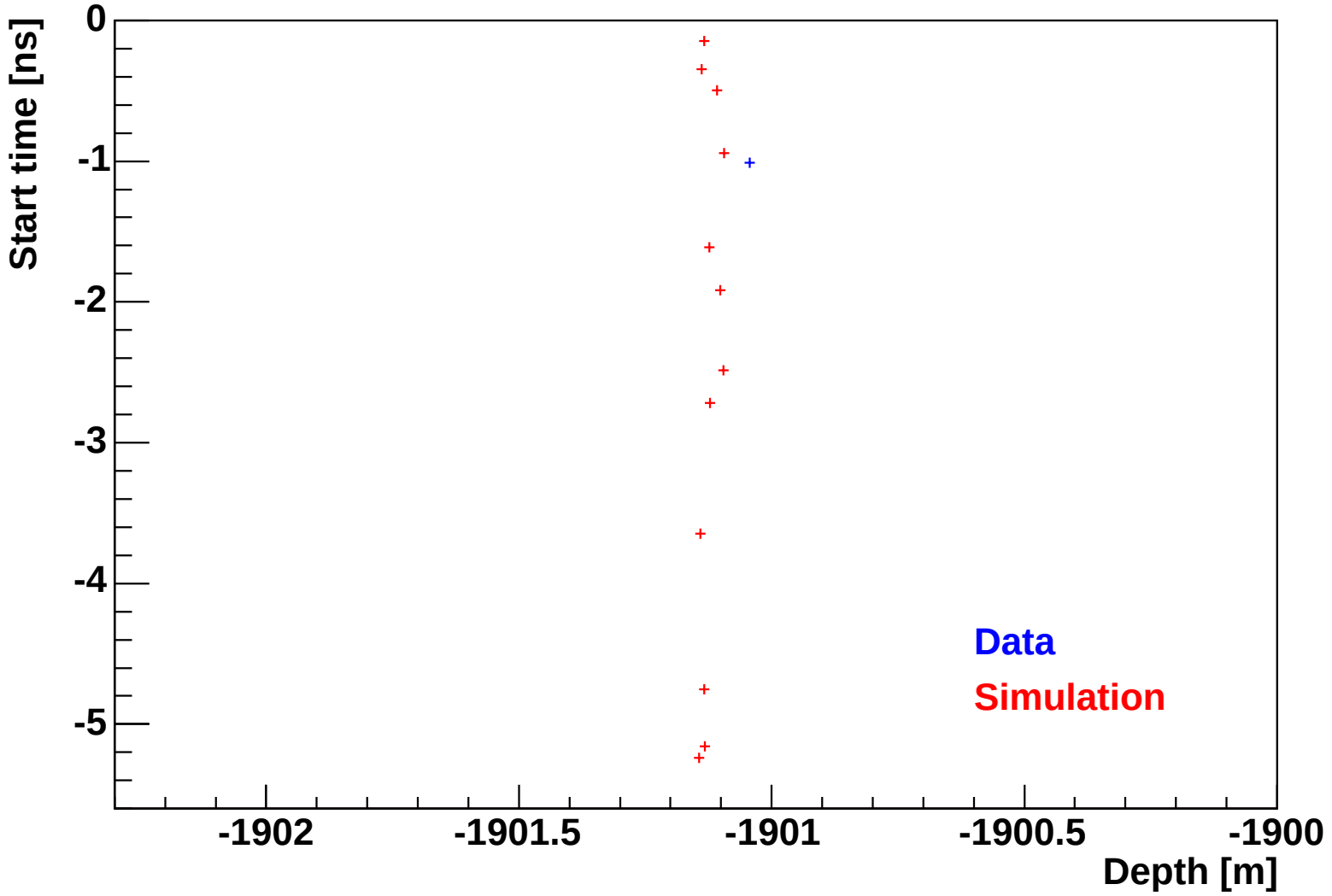
- Timing jitter in electronics? Might see in start time of nearby waveforms

- Arrival time of first photons provide info on:

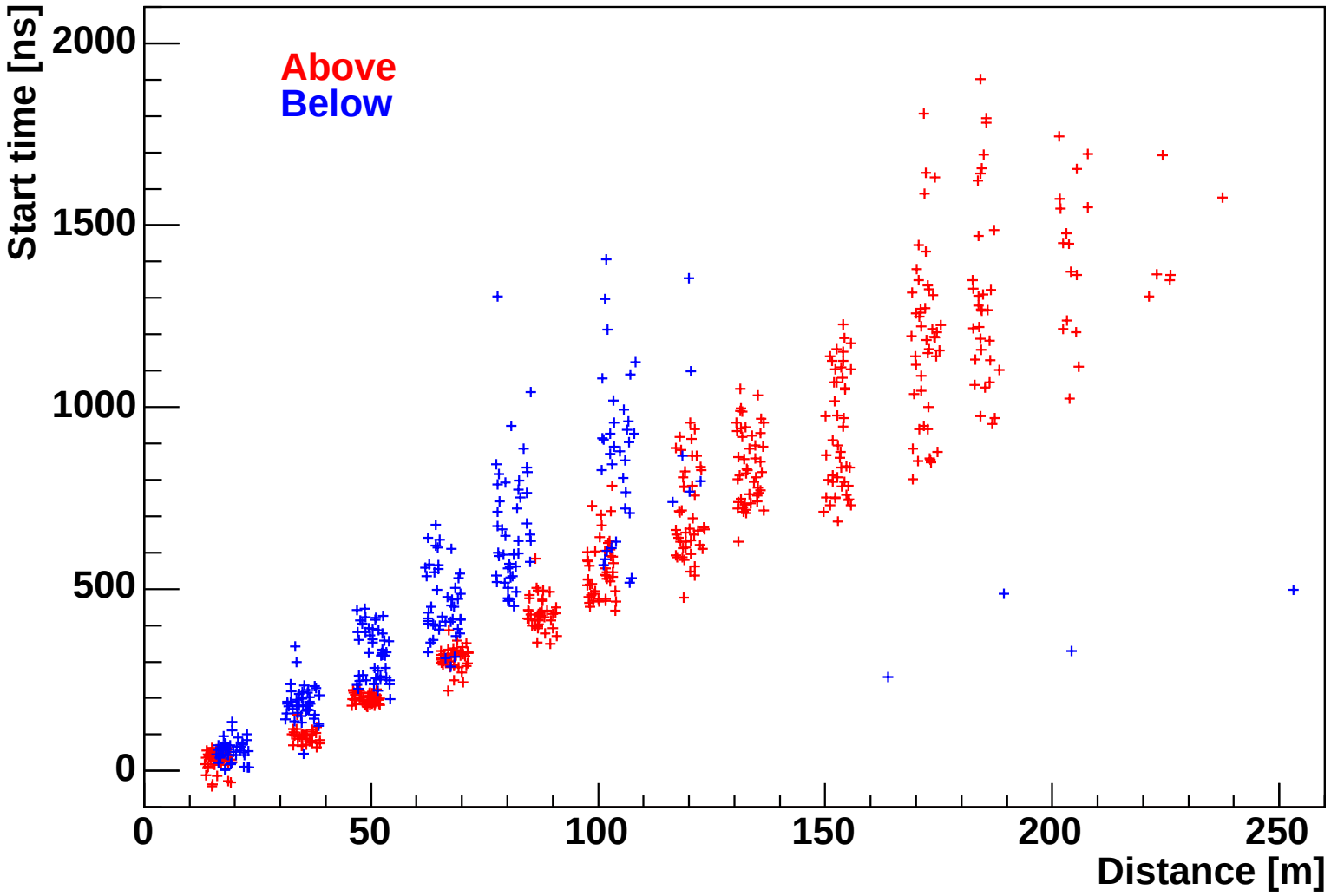
  - upward/downward asymmetry in DOM sensitivity
  - upward/downward asymmetry in flasher brightness
  - circuitous paths – ice quality and relevant propagation model


Start time v. Depth (DOM 30 Data and DOM 30 Simulation)
Start time [ns]
2500
2000
1500
1000
500
0
-2200
-2100
-2000
-1900
-1800
-1700
-1600
Depth [m]
Data
Simulation

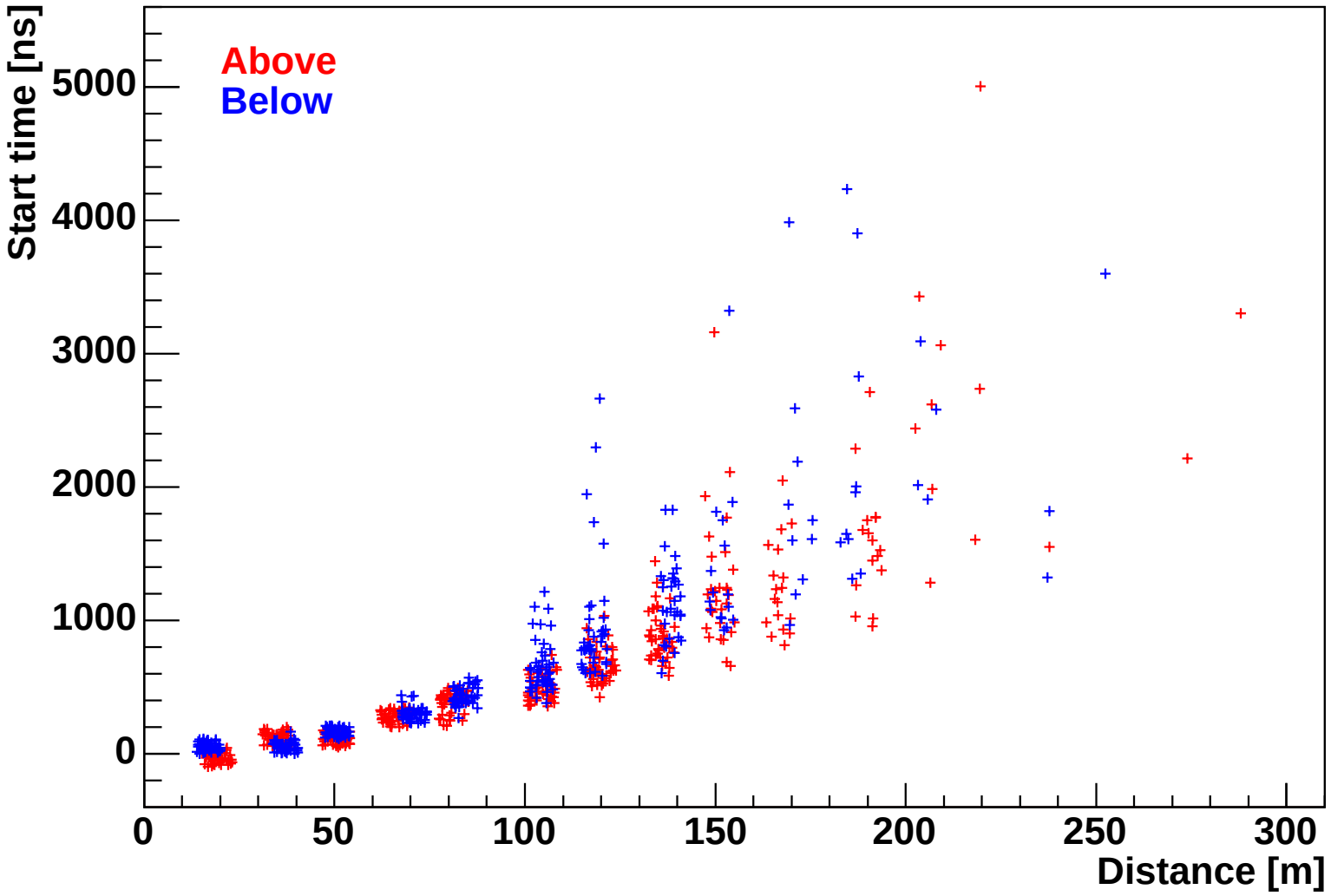
Start time v. Depth (DOM 30 Data and DOM 30 Simulation)



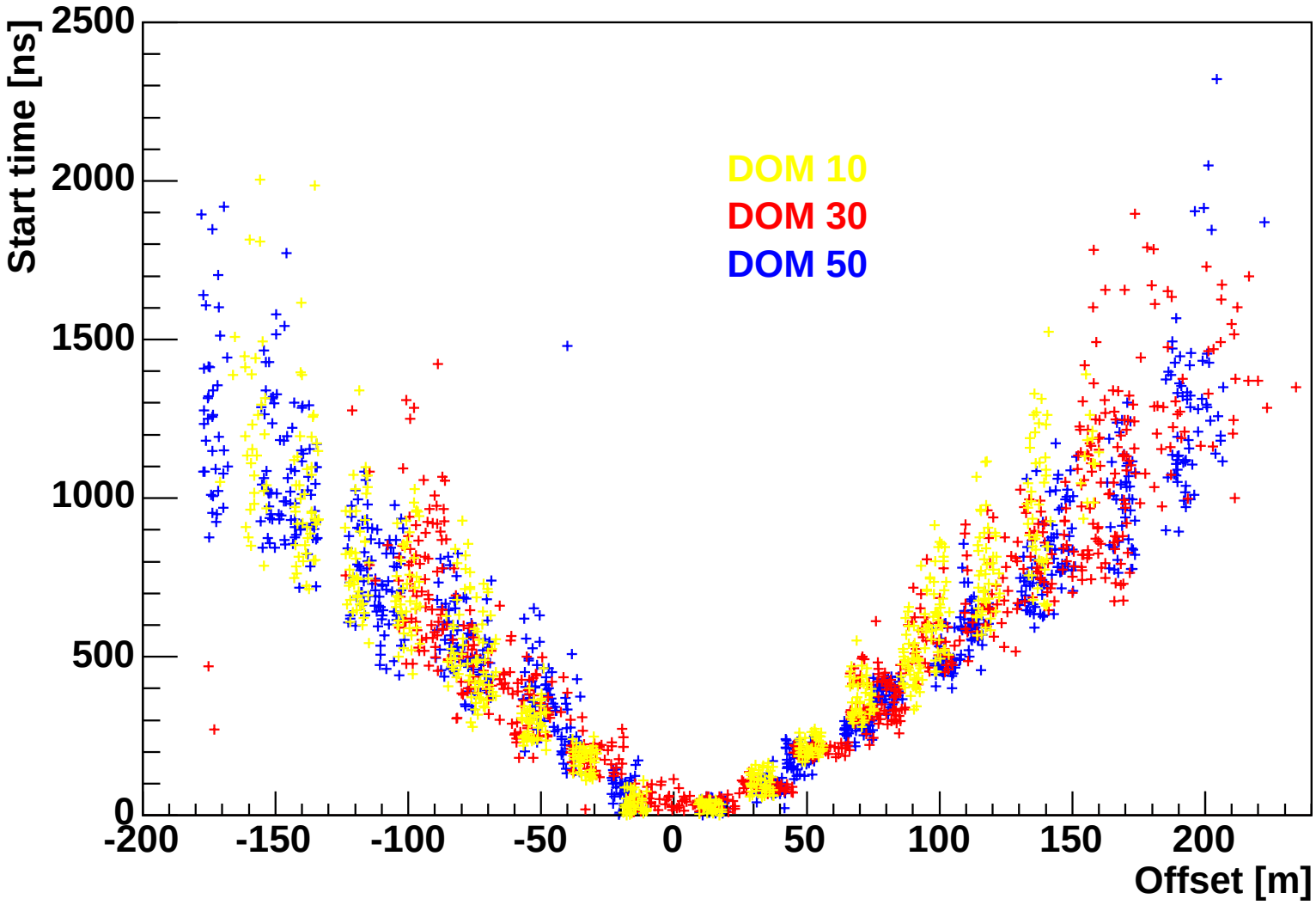
Start time v. Distance from flasher (DOM 30 Data Above and Below)



Start time v. Distance from flasher (DOM 30 Sim Above and Below)



Start time v. Offset from flasher (DOMs 10, 30, 50)

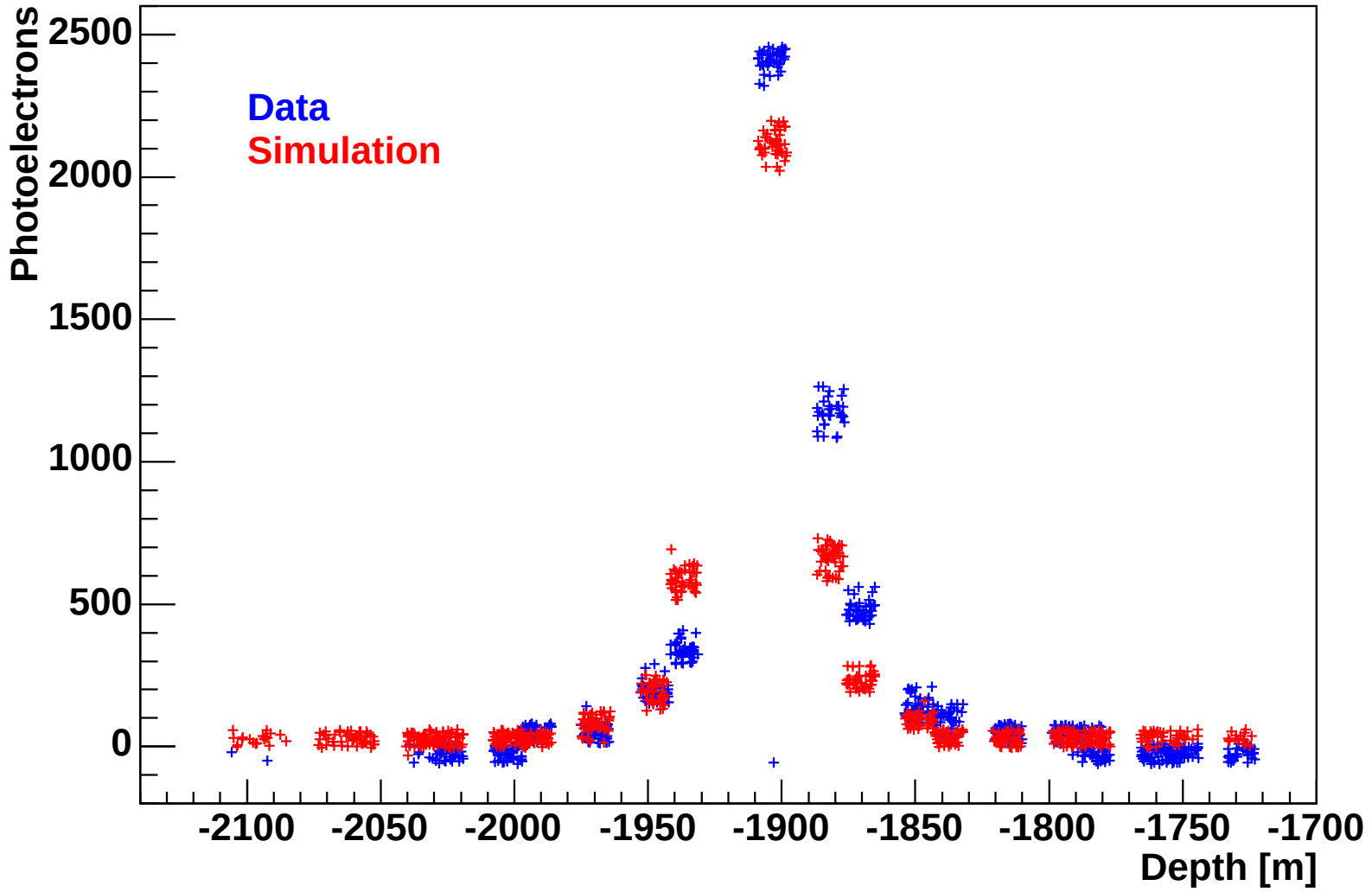


Total photoelectrons at different DOMs

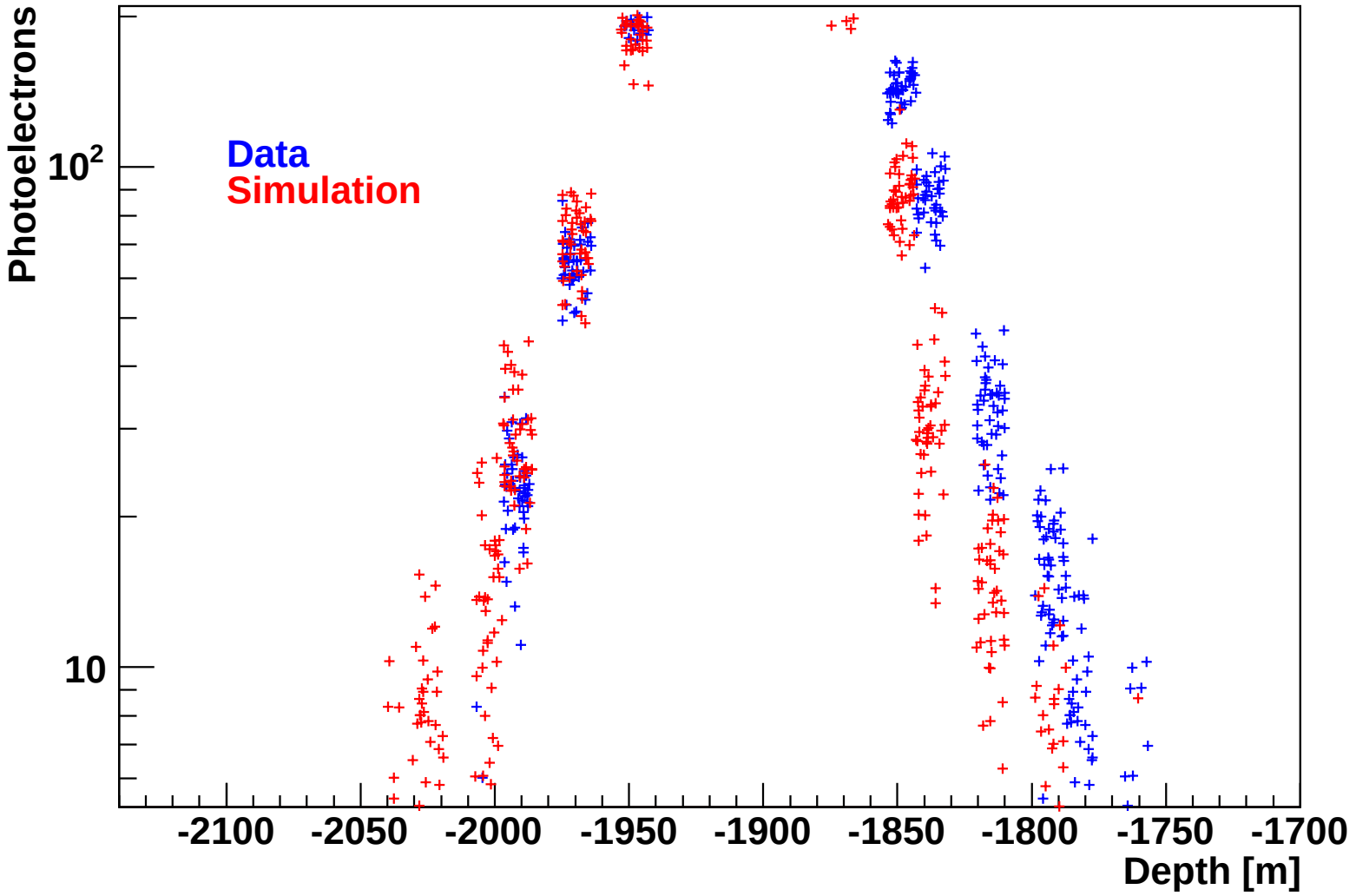
- How calculated:
  - Runs have 128 bins $\times$ 3.3 ns $=$ 400 ns waveform
  - Used first bin as pedestal (doesn't account for droop)
  - $$\text{charge} = \sum_{i=1}^{128} \Delta t \left(\frac{V_i - V_1}{50\Omega} \right)$$
- Elements of calibration to consider:
  - Up/down asymmetry in sensitivity
  - Shadowing by nearest DOMs and scattered paths?
  - Dependence of these effects on ice quality

- Also examine peak photoelectron rate

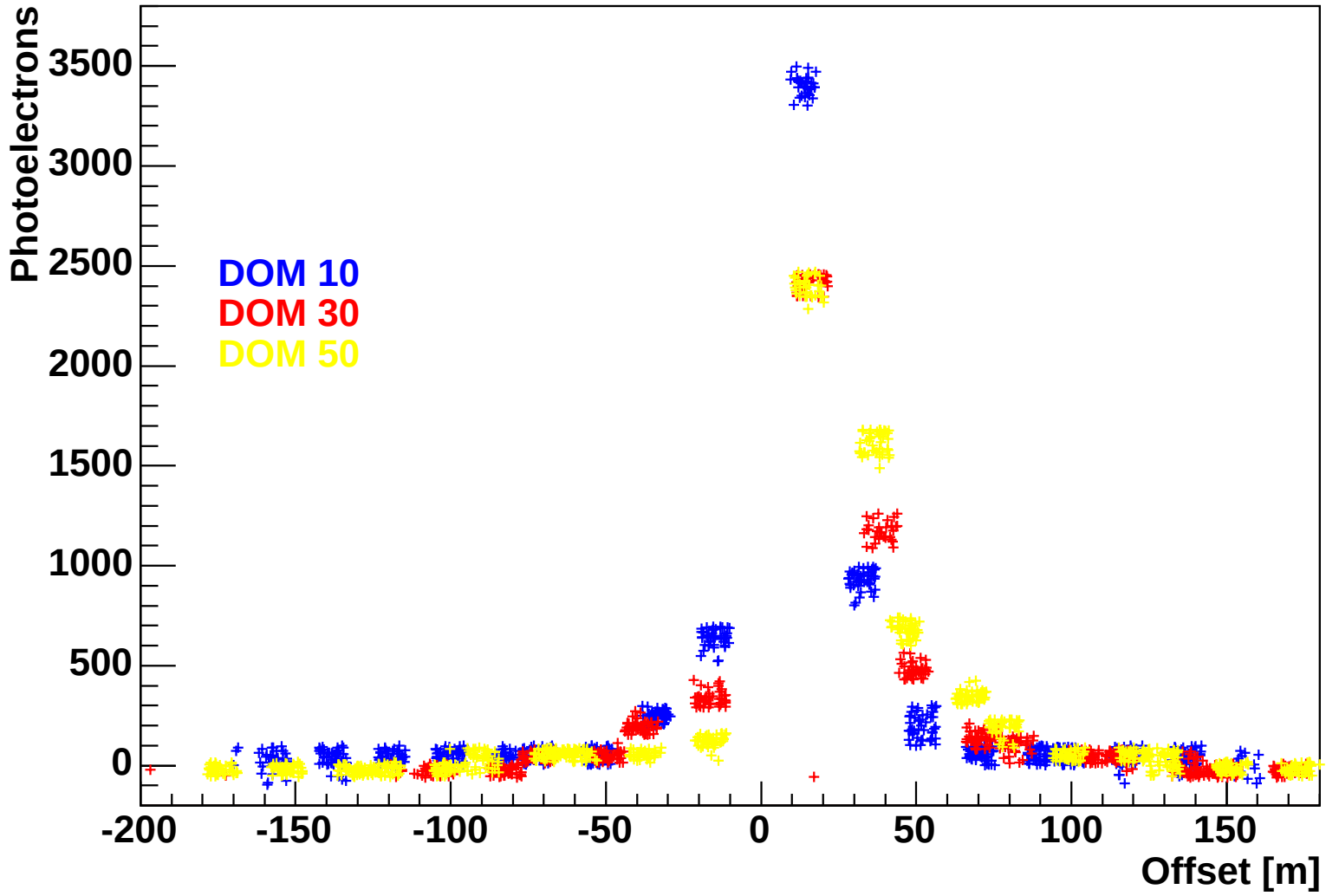
Total photoelectrons v. Depth (DOM 30 Data and DOM 30 Simulation)



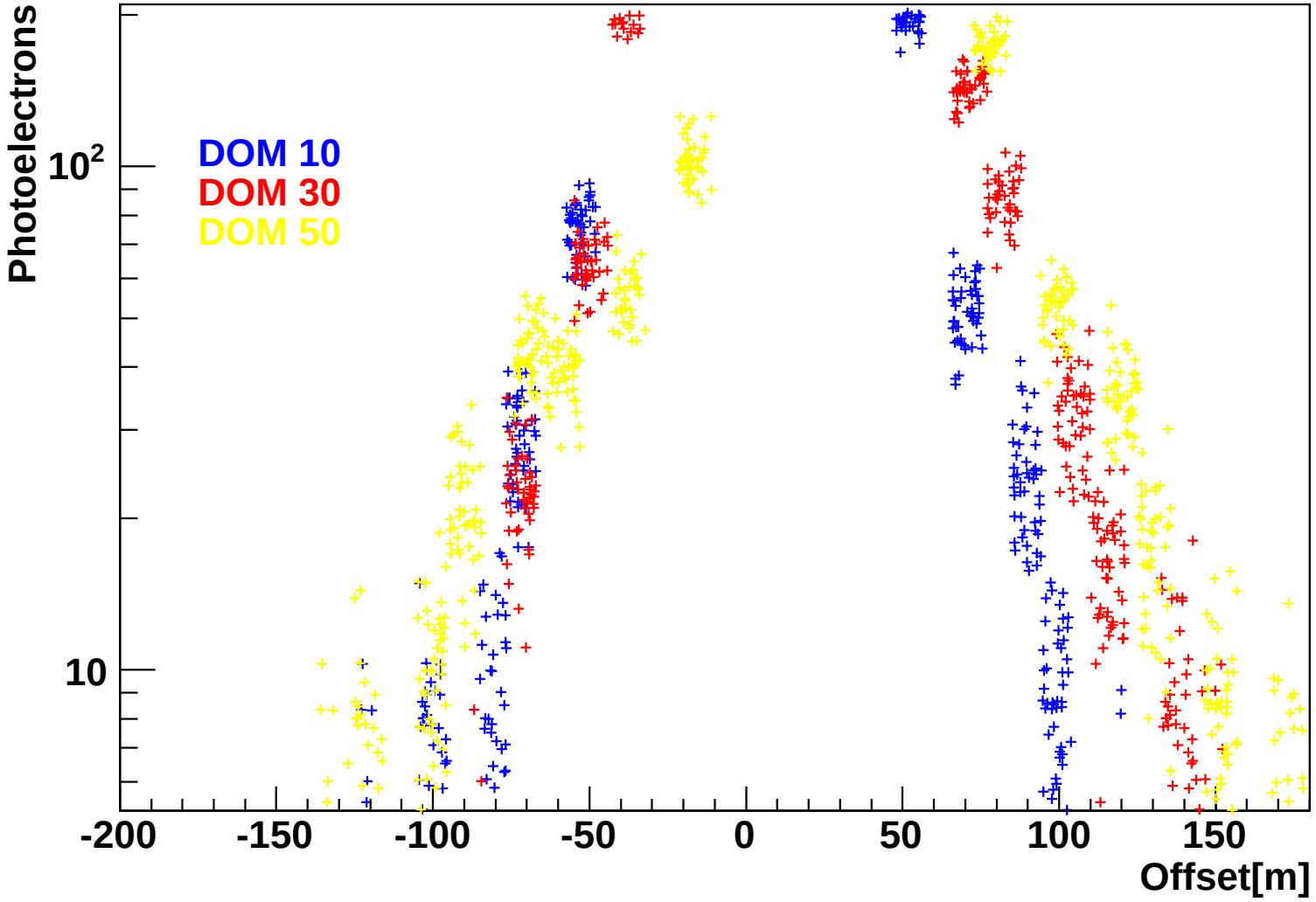
Total photoelectrons v. Depth (DOM 30 Data and DOM 30 Simulation)



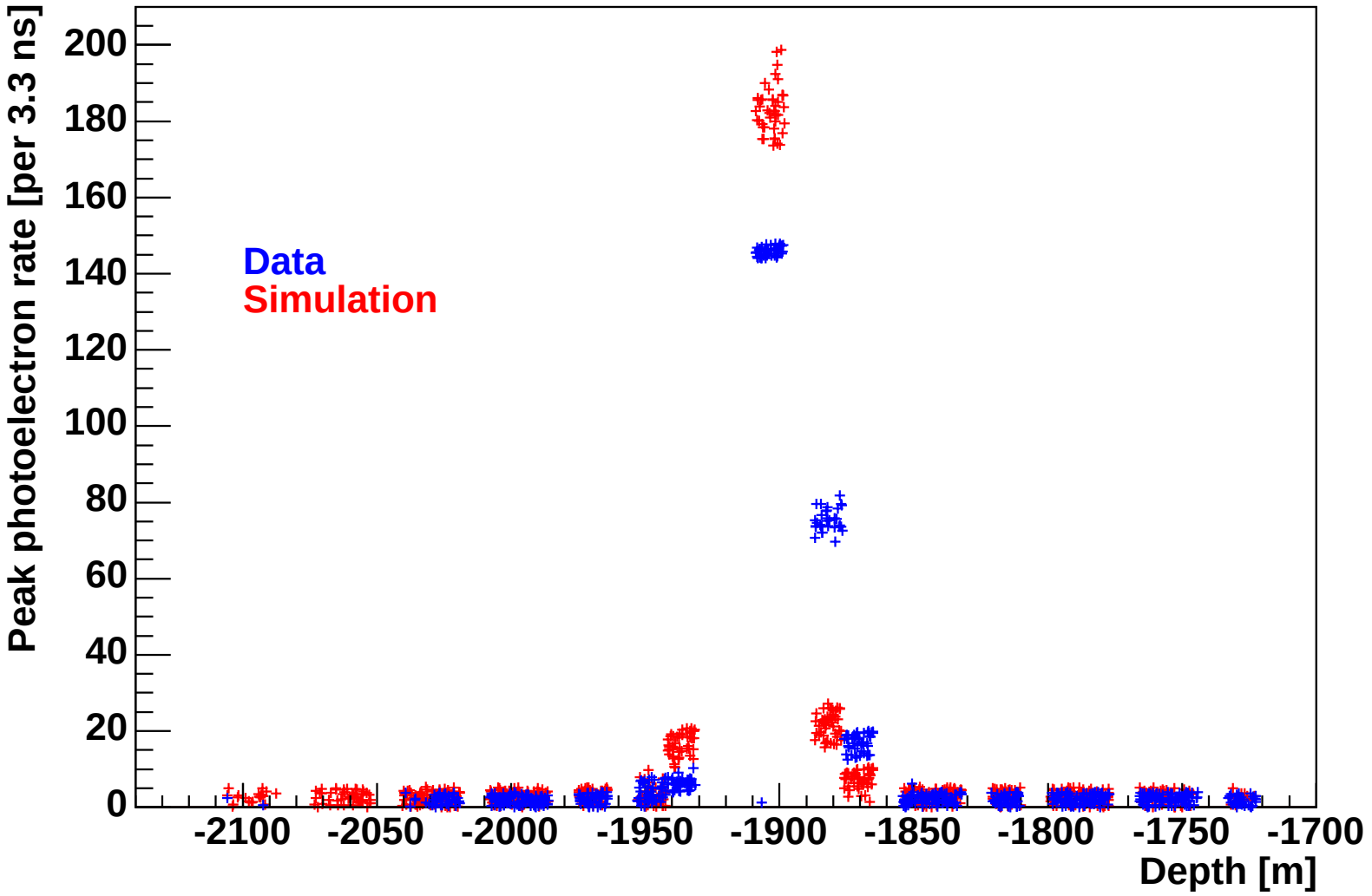
Total photoelectrons v. Offset from flasher (DOMs 10, 30, 50)



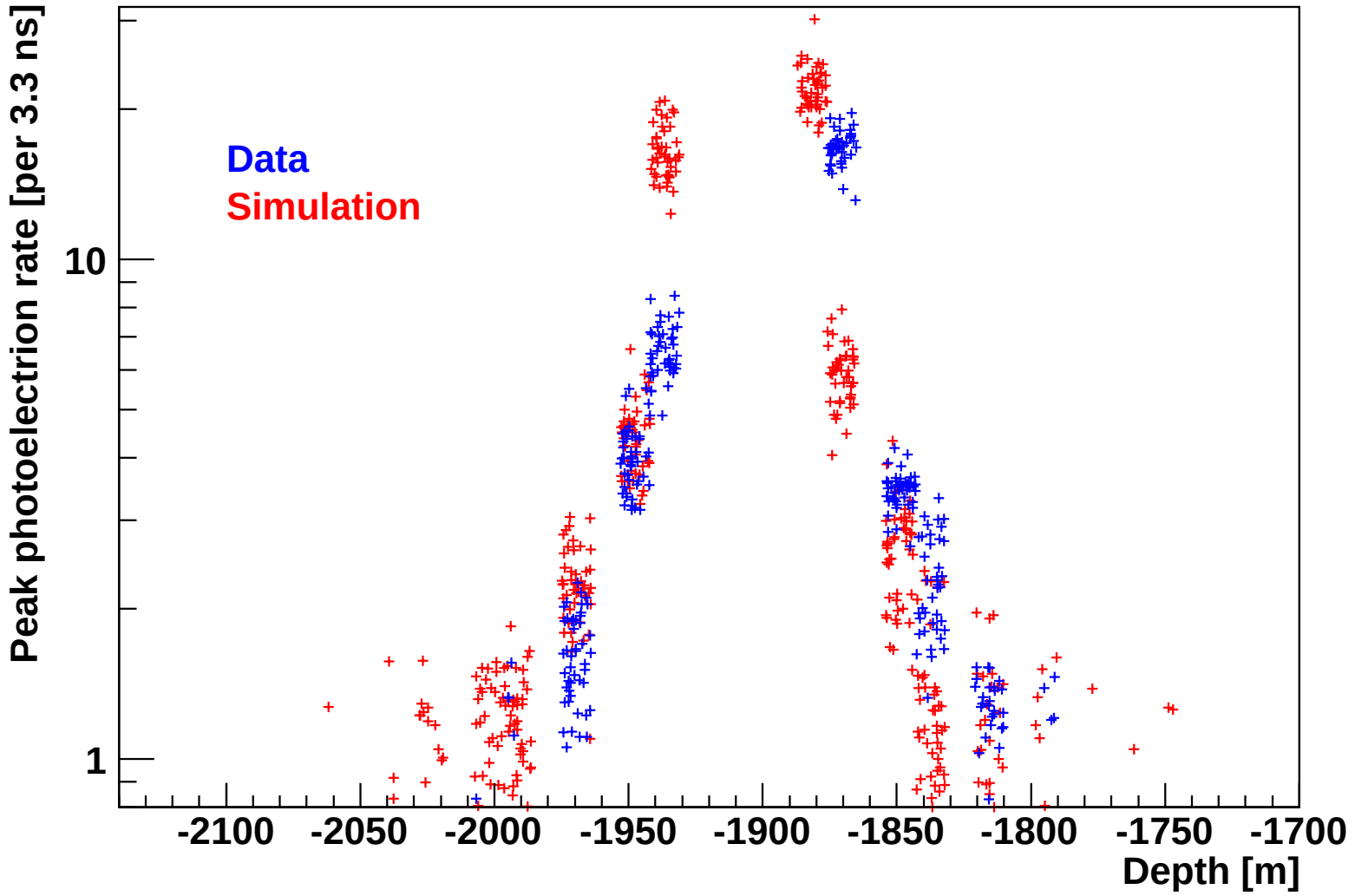
Total photoelectrons v. Offset from flasher (DOMs 10, 30, 50)



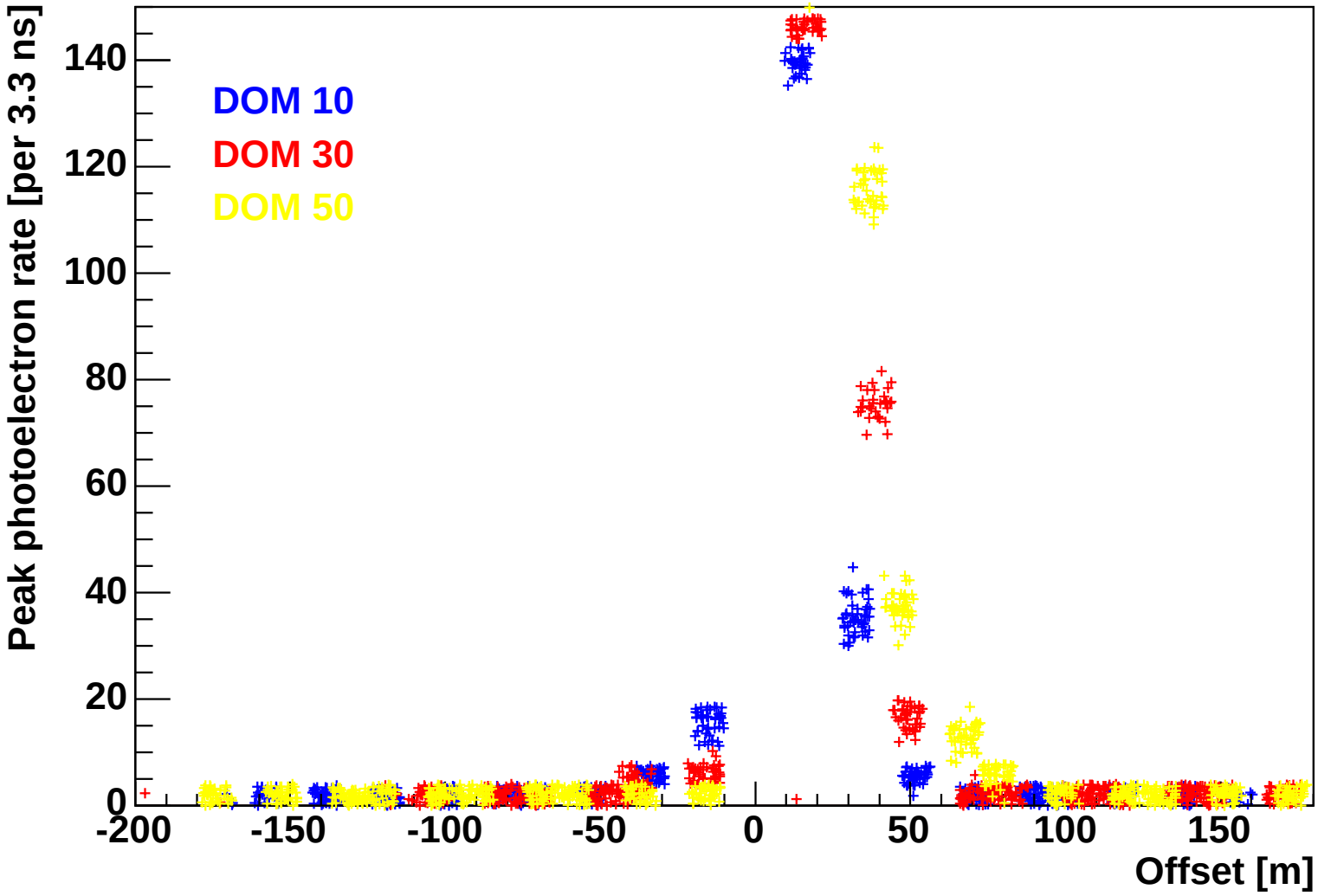
Peak photoelectron rate v. Depth (DOM 30 Data and DOM 30 Simulation)



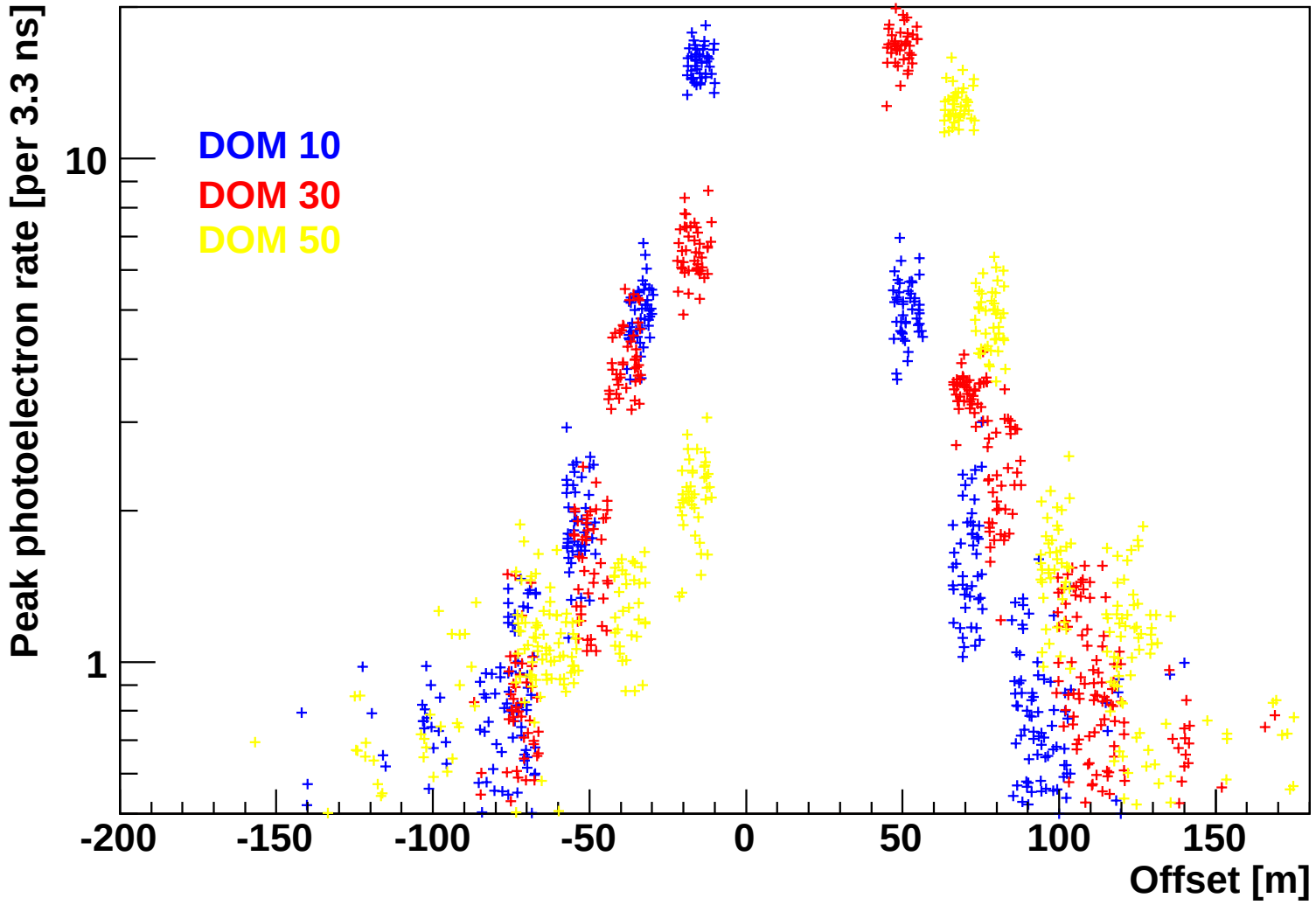
Peak photoelectron rate v. Depth (DOM 30 Data and DOM 30 Simulation)



Peak photoelectron rate v. Offset from flasher (DOM 10, 30, 50 data)



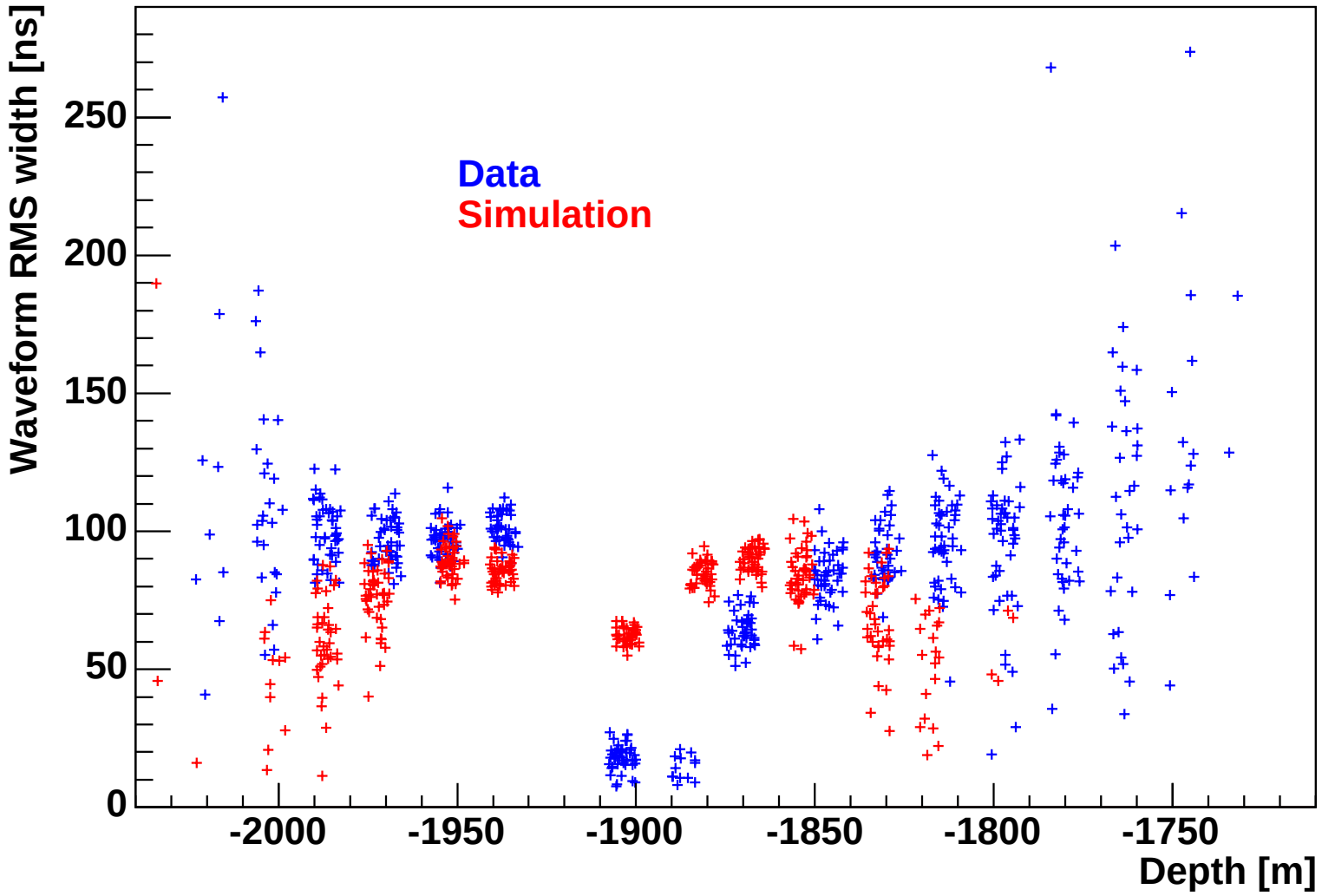
Peak photoelectron rate v. Offset from flasher (DOM 10, 30, 50 data)



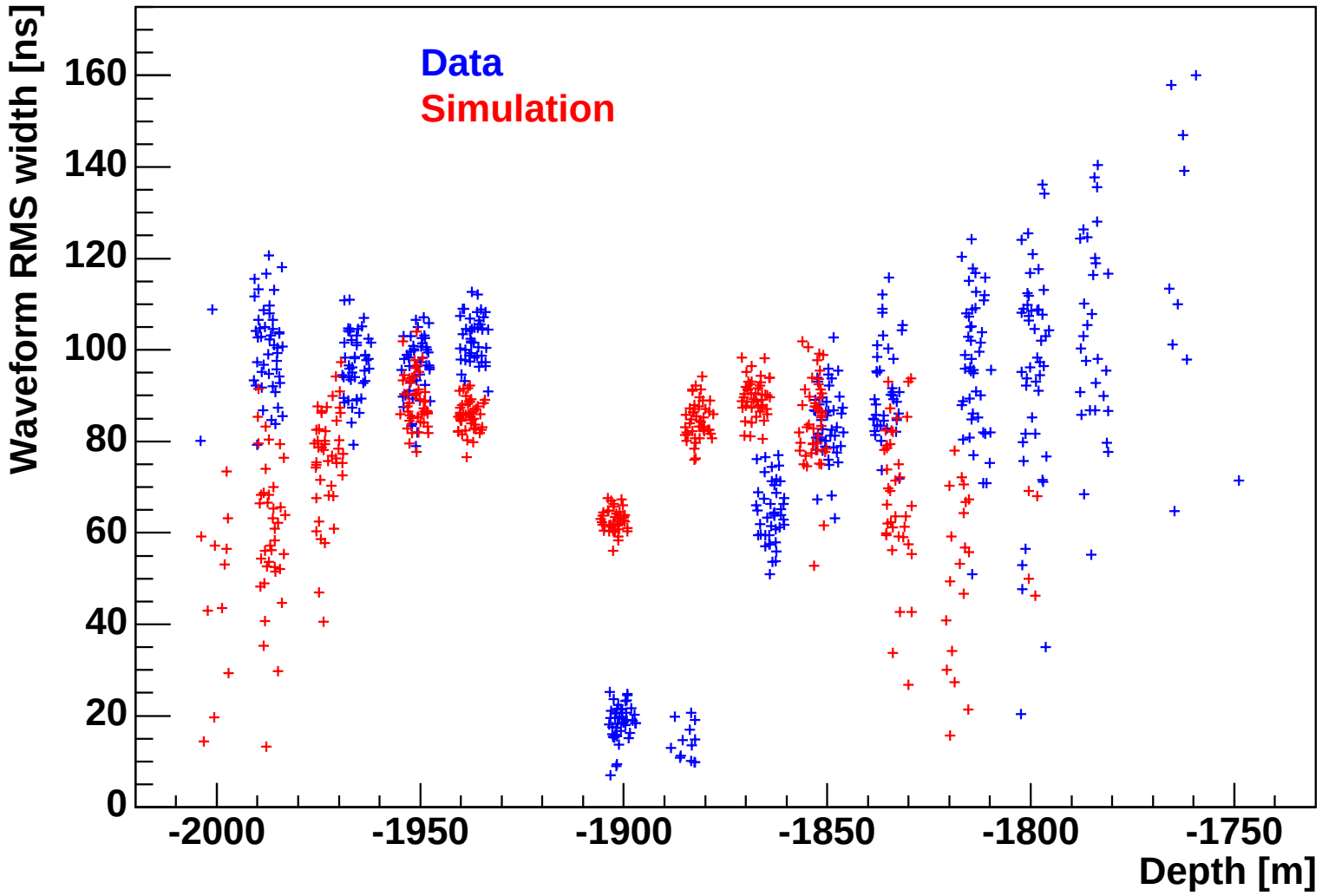
Waveform width and photon propagation models

- Waveform width $\sigma_t \sim R$ independent of energy
- Want to fit to model, but need absolute brightness – using RMS
- Conv. Pandel and diffusion both have linear width at large R, but Pandel levels off at small R
- **George J.**: model parameters can be found from slope of line
- Again, must consider shadowing and asymmetry in sensitivity

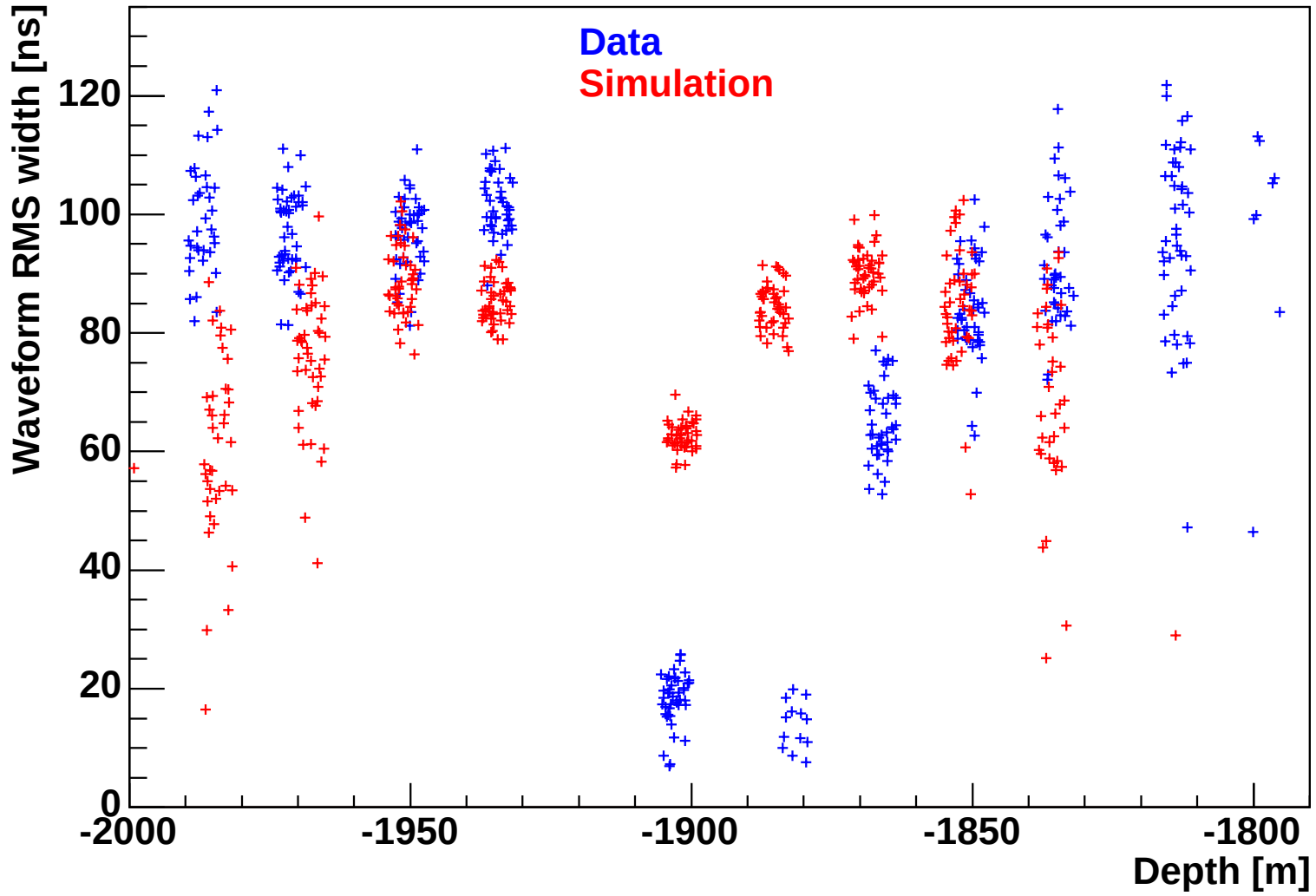
Waveform RMS width v. Depth (DOM 30 Data and DOM 30 Simulation)

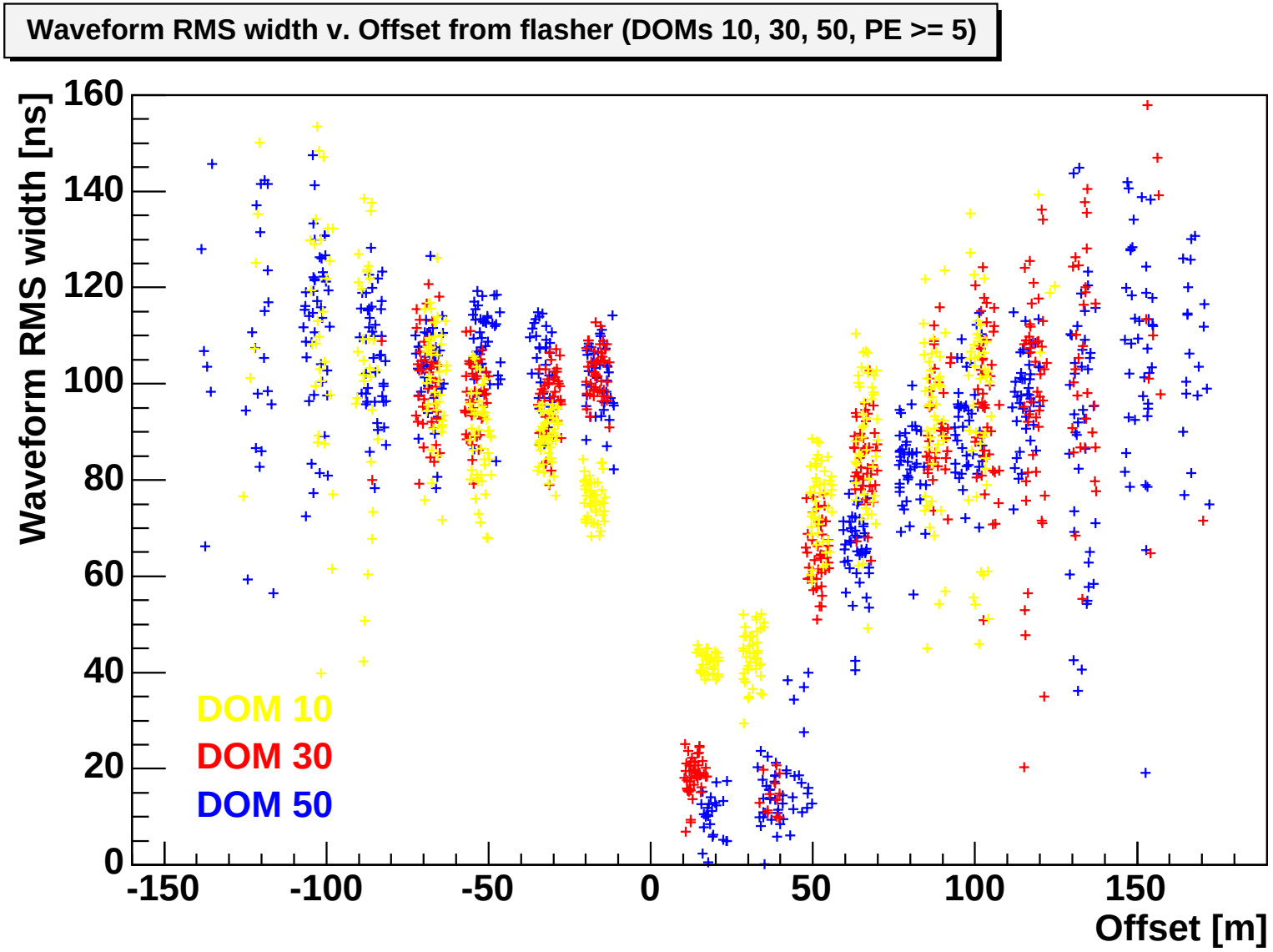


Waveform RMS width v. Depth (DOM 30 Data + Simulation, PE >= 5)



Waveform RMS width v. Depth (DOM 30 Data + Simulation, PE >= 20)




Waveform RMS width v. Offset from flasher (DOMs 10, 30, 50, PE >= 5)
Waveform RMS width [ns]
160
140
120
100
80
60
40
20
0
-150
-100
-50
0
50
100
150
Offset [m]
DOM 10
DOM 30
DOM 50

renew ν_e Cascade Reconstruction

- ν_e showers localized; interested in vertex and direction
- Figure of merit:

$$\chi^2 = \sum_{i \in \{\text{DOMs}\}} \frac{\left(\vec{X}_i - \vec{X}_c\right)^2 - R_i^2}{(\sigma_R)_i^2}$$

where

– $\vec{X}_i$ is DOM position

- $\vec{X}_c$ is shower location
- R_i is distance tabulated from waveform width, etc.
- $(\sigma_R)_i^2$ is uncertainty in distance tabulated from waveform width, etc.

- Must characterize invertibility of $\{\text{waveform props.}\}_i \mapsto \{R, \sigma_R\}_i$
  - Mathematical measures
  - Flasher reconstruction?

Future

- Implement `renew` and test on Monte Carlo
- Introduce layered ice photonics to simulation, compare
- Test conv. Pandel and diffuse photon propagation models; mix models in reconstruction of unknown ice to improve reconstruction χ^2?